Research Note 81-14

REPRESENTING AND DISPLAYING INFORMATION
FOR TACTICAL DECISION PROCESSING

Albert N. Badre
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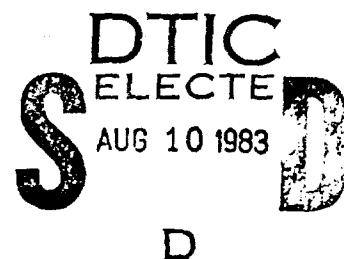AUG 10 1983

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One of the main tasks required in developing user-compatible systems is the specification of criteria for the development of algorithms that search for, classify, and order the display of chunks of tactical information such that they are meaningful to the decision maker. In previously completed ARI Research, the focus had been on designing experiments to locate and determine various characteristics of the informational chunks that decision makers formulate when viewing and analyzing static map positions of tactical situations.

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The aim of this study was two-fold: (a) to investigate the effects of the sequential displaying of chunks on the assimilation of tactical information; and (b) to determine the effects of presenting a tactical scenario as a member of a sequence of scenarios on chunking.

Two experiments were designed and conducted. The general procedure was to utilize battlefield scenarios to be reconstructed and copied under varying conditions of presentation and viewing by a select group of battlefield commanders (participants). The first experiment examined the hypothesis that if tactical information is presented to the participant incrementally and sequentially by meaningful chunks, it is likely to lead to greater information assimilation(measured by recall accuracy) than if the same information is presented either by a sequence of non-meaningful chunks or all at once. Also, it was conjectured that the order of presentation of meaningful chunks will have a significant effect on assimilation performance. The results indicated that presenting information sequentially and incrementally by meaningful chunks leads to higher recall accuracy than if the same information is presented either in non-meaningful chunks or in meaningful chunks that are viewed in an order different from that of the original reconstruction. Those results suggest that not only is it important to present information in meaningful structures, but in the case where the information can not be presented all at once, the effectiveness of information assimilation increases when the meaningful structures are presented in a proper sequence.

The second experiment examined the effects of varying the placement of the criterion scenario in a sequential context on chunking characteristics and accuracy of recall. The findings show no difference in accuracy of recall under varying contextual conditions, suggesting that the viewer's recall strategy is to foreground the entire sequence of scenarios, not only the one to be reconstructed. Sequential context had no effect on chunk size. The availability of an invariance in the sequence of scenarios had a significant effect on the order in which symbols were reconstructed and on chunk content.

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Representing and Displaying Information for

Tactical Decision Processing

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1.   Introduction

It is well recognized that the effective management of

tactical information is one of the major problems faced in command

decision making. A commander has to gather, represent, process,

assimilate, and use large amounts of information, often in

situations of rapidly changing tactical scenarios, in relatively

short time periods. One proposed way to cope with the information

management problem has been through the design and use of command

and control decision-aiding systems such as the Army's Tactical

Operations System

There is a growing consensus that such on-line decision-

aiding and information management systems become increasingly useful

when they are designed to be front-end user-compatible (Palme, 1975;

Miller and Thomas, 1977; Miller, 1977; Badre, 1979).   Because

computer decision systems are "information processing" ones, they

are likely to be more user-compatible if they are designed to

adapt to the information processing capabilities and limitations

of the user. For example, it is well recognized that in general
a computer system can augment the user's limitations effectively
for tasks that require large amounts of time to perform manually,
or that are dependent for success on either rapid processing
times or exhaustive search capabilities. On the other hand, tasks
that require heuristic search strategies are likely to be performed
more successfully by humans than by machines.

For tactical decision situations, one of the main tasks
required in designing user-compatible on-line systems is the
specification of criteria for the development of algorithms that
search for, classify, and order the display of chunks of tactical
information such that they are meaningful to the decision-maker.
The identification of meaningful chunks and the order in which they
are to be displayed for rapid processing and assimilation in
decision making requires the implementation of well conceived
experimental data collection techniques. In the previously funded
research project by the Army Research Institute* the focus had
been on designing experiments that permitted us to locate and
determine various characteristics of the informational chunks that
novices and experts formulate when viewing and analyzing static
map positions of tactical situations. It was clear from the data

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analysis that meaningful chunks of information are identifiable

for coherent (structured) battlefield map positions. In

addition, for coherent positions, the size of the chunks as well

as the frequency with which meaningful chunks are formulated

were significantly greater than the size and frequency for

noncoherent positions. It was also clear from the initial data

analysis that the average chunk is composed of a number of

relations between unit designator symbols. Chunked relations

tended to occur associatively with high frequency over subjects.

Given the above results, the aim of this study was to investigate

the effects of the sequential displaying of chunks on the

assimilation of tactical information as well as the effects of

presenting dynamic tactical situations with invariant features

on the characteristics of chunking.

2.   Rationale and Context of Research

In the previously funded project by the Army Research Institute

(Badre, 1979), the underlying thesis, borrowed from and supported

by previously completed research on tactical games (Badre, 1979;

Frey and Adesman, 1976; Chase and Simon, 1973), is that the

expert analyzes and processes the viewed battlefield positions in

terms of well formed structures (chunks), and that these structures

provide the basis for selecting and valuating the foregrounds of

play or action. The information to which the problem solver (e.g.,

the battlefield commander) attends on a given position constitutes

the foreground of that position. The well formed structures are the tools and elementary vocabulary, possibly non-verbal, used in foreground perception and synthesis. Furthermore, when the constraint of sequential processing applies, as it may in the viewing and analysis of on-line displays, the expert problem solver is likely to process his information in an incremental predetermined order of meaningful chunks.

The implication of the chunking conjecture for the design of on-line decision systems is that in order to make such systems user-compatible, the informational characteristics and order in which information is to be displayed would have to conform to the rules of chunking identified in the user's practices and behaviors. But in order to relate the chunking conjecture more realistically to battle situations, we must consider the effects of dynamic tactical scenarios on chunking. It seems reasonable to assume that in dynamic battle situations (i.e., situations where for example active defense tactics are employed and where possibly every six kilometers of enemy advance require a new battlefield scenario), the underlying representation for selecting a set of structures and their associated foregrounds is not governed solely by or limited to the unique scenario under analysis. Rather, it stems as well from the given position's relations to the sequence of battle positions that were its

immediate predecessors as well as those that are immediately
anticipated by it.

Accordingly, in addition to testing the sequential-
presentation-of-chunks conjecture, it is worthwhile to begin
investigating the effects of a line of play or battle action on
the expert's representation as it may be manifested in the
characteristics of his chunks and perceived foregrounds. Several
key questions need to be explored regarding representations
arising from the considerations of lines of actions and positions
in contrast to considerations of single positions. For example,
what in practice is an appropriate algorithmic representation for
a line of actions? How does the battlefield commander construct
his algorithm as a basis for executing an action? What are the
atomic action components of such algorithms; i.e., what constitutes
an action? For example, in a tactical game, are the actions a
set of valued moves or a set of valued associations between
structures, configurations, states, or foregrounds? Is a line
of associated foregrounds itself a well formed foreground or is
it simply a set of discrete positions that are sequentially
related by a search or move algorithm? Do the chunking charac-
teristics of a position change as a function of its placement in
a sequence? These are some of the short and long range questions
about chunking and representation of battlefield scenarios that

would need to be investigated for designing effective tactical decision-aiding systems.

3. Objectives

The general theme of this study is that the expert represents, stores, and retrieves tactical information in meaningful chunks, and that the informational characteristics of those chunks vary as a function of the length of the battle segment to which the commander is exposed. Accordingly, the goal of this study was to investigate experimentally the following conjectures:

a) For effective on-line display techniques, if tactical information from a battlefield map is presented sequentially and incrementally by meaningful chunks, it will result in higher assimilation and recall than if it is presented in a sequence of non-meaningful chunks;

b) Likewise, sequentially presented meaningful chunks will result in higher recall than simultaneously presented chunks;

c) Chunking characteristics will differ if a battlefield scenario is presented out of context under one condition and then presented as a member of a sequence of scenarios under another condition;

d)   Given a coherent sequence of battlefield scenarios,
one where the scenarios fall logically and realistically
in the order presented, both accuracy of recall and
chunking characteristics will not differ significantly
as a function of the ordinal of placement of the
criterion scenario (the one to be reconstructed) in
the sequence;

e)   Given a random non-coherent sequence of battlefield
scenarios, chunking characteristics and accuracy of
recall will differ significantly as a function of the
criterion scenario's position in the sequence
suggesting recency of presentation and memory
differential effects.

4.   Research Methodology

In order to examine the above stated conjectures, two
experiments were designed and conducted. The general procedure
was to utilize battlefield scenarios to be reconstructed and copied
under varying conditions of presentation and viewing by a select
group of battlefield commanders (to be referred to as participants).
In the simplest form of the reconstruction task, the participant
is first shown a battlefield scenario. He is permitted to study
the scenario for a prespecified amount of time after which it is

removed and he is asked to reconstruct it. As the participant
is reconstructing the scenario symbols, the experimenter makes
certain time and symbol placement order recordings. In the
copying task the participant is given the same battlefield
scenario as in the reconstruction task and is asked to copy it
on a blank diagram as rapidly and as accurately as possible. The
same type of data is recorded here as in the reconstruction task.
The data is used jointly from both tasks to determine accuracy of
recall and chunk boundaries. The intent is to use those techniques
in order to analyze the effects of varying the presentation of
information in the battlefield scenario on both accuracy of
recall and chunking characteristics. Accordingly two experiments
were conducted along the lines described below.

4.1   Experiment I.   The finding of ongoing and previously
reported research (Badre, 1979; Chase and Simon, 1973; Frey and
Adesman, 1976) that in problem solving situations displayed
information is encoded and represented by the expert in meaningful
chunks leads to the suggestion that on-line displayed tactical
information should be developed for the user in discrete
meaningful chunks. Accordingly the conjecture to be examined here
is that if tactical information is presented to the battlefield
commander incrementally and sequentially by meaningful chunks,
it is likely to lead to greater information assimilation (measured

by recall accuracy) than if the same information is presented
either by a sequence of non-meaningful chunks or all at once.
Also, it is conjectured here that the order of presentation of
meaningful chunks will have a significant effect on assimilation
performance.

4.1.1 Subjects. Thirty-six volunteer military officers
from Fort Benning, Georgia were selected on the basis of experience
to participate in the experiment.

4.1.2 Material. The material for this experiment consisted
of the three structured battlefield scenarios (see Appendix I)
used in earlier research (Badre, 1979). The symbols of each
scenario were grouped into two sets of chunks. One set consisted
of meaningful chunks and the other of non-coherent chunks whose
constituent symbols are not likely to be related in meaningful
patterns. The degree of meaningfulness (coherence) of a chunk for
a given scenario and the order in which it was presented are based
on the previously collected data (Badre, 1979). The scenarios
were developed and presented on film.

4.1.3 Design and Procedure. Comparisons were made among four
basic display conditions. These are: (1) the one-shot display of
the scenario; (2) the development of the scenario incrementally
by chunks in an order that is already established by last year's

results; (3) the development of the scenario by chunks in the
reverse of the already established order; and, (4) the development
of the scenario incrementally by the addition of non-meaningful
chunks.

Three structured scenarios, P_1, P_2, and P_3 were used, each
in the four presentation modes described above. The officers
were randomly assigned to four groups of nine participants in
each group. Each participant was shown the three scenarios,
whereby he saw each scenario in one of three of the four different
modes of presentation. The presentation of scenarios was counter
balanced within each group to average out possible order effects
on performance. Table 1 shows how the presentation modes and the

Table 1. Summary of Scenarios x Groups x
Modes of Presentations

Scenarios \ Groups	A	B	C	D
P_1	Meaningful chunks (M)	Non-Meaningful chunks (N)	All-at-once (A)	Meaningful chunks-(MR) reverse
P_2	All-at-once	Meaningful chunks-reverse	Non-meaningful chunks	Meaningful chunks
P_3	Non-meaningful chunks	Meaningful chunks	Meaningful chunks-reverse	All-at-once

scenarios were distributed over the groups. Scenarios were

sequenced on a movie film in such a way that the three scenario

presentations for a participant in a group could be processed

in order by always skipping forward on the film, as in the

following example:

$$
A \begin{cases}
P_1 & M \\
P_2 & A \\
P_3 & N \\
P_1 & M \\
- \\
-
\end{cases}
$$

$$
B \begin{cases}
P_1 & N \\
P_2 & MR \\
P_3 & M \\
- \\
- \\
-
\end{cases}
$$

Each participant was told that this is an experiment in

information processing. He was told that an experimental run

would consist of three trials. In each trial a battlefield

scenario would be displayed briefly on film. The scenario may

be shown all at once in one exposure or may be developed incre-

mentally in a sequence of several film frames, each frame lasting

between two and three seconds. After eighteen seconds of viewing time, the scenario was removed and the participant was asked to reconstruct it on a sheet of paper that has on it the outline of a battlefield background. For reconstructing the scenario, the participant used rubber stamps with the proper symbols. A pre-test slide was used for practice. The reconstruction task was followed immediately by the copying task. Here the participant was asked to copy the symbols on each slide as accurately and as rapidly as possible.

4.2 <u>Experiment II</u>. The overriding theme motivating this experiment is that in real battle analysis, the underlying representation as manifested in chunking and foregrounding behaviors resides not in the single position under analysis, but in a time sequence of related battlefield scenarios. In order to examine the three previously-stated conjectures that are related to this theme (see the section on objectives), an experiment was designed where the criterion scenario to be reconstructed was presented under different conditions of sequencing.

4.2.1 <u>Subjects</u>. Thirty-five of the previous thirty-six officers participated in this experiment. They were randomly assigned to five groups of equal size.

4.2.2 Material. The material for this experiment consisted of a sequence of nine distinct scenarios that follow each other in a realistic order of battle action (see Appendix II). The sequence represented nine distinct battlefield positions where movement over time gave rise to new battlefield scenarios. The scenarios were presented to the participant in ordered sequences of five scenarios at a time.

4.2.3 Design and Procedure. The thirty-five participants were randomly assigned to five equal groups and underwent the same procedure for the reconstruction and copying tasks as in Experiment I. Each group was associated exclusively with one of five modes of presentation. The modes of presentation differed on the position where the scenario-to-be-reconstructed, #6 (see Appendix II), occurred as shown below:

a)   6 7 8 9 10   (f is first

b)   4 5 6 7 8   (6 is middle)

c)   2 3 4 5 6   (6 is last)

d)   6   (alone)

e)   9 1 6 8 2   (6 in middle, out-of-sequence order).

Under each mode, the complete line of scenarios was presented on a rectangular cardboard at once and held in view for forty-five

seconds before being removed. Then immediately the display was changed and a blank "map" was placed in the position where scenario #6 had occurred indicating that the participant should reconstruct #6.

After both experiments were finished, sixteen participants were asked to perform the copying experiment (as described in the proposal). Each participant copied only one of the four scenarios used in both experiments. Thus, each scenario was copied by four different participants. Another eighteen partici- pants were asked to perform a "circling" procedure on the four scenarios. Here, the participants were given a copy of each of the scenarios and were asked to enclose within one circle the symbols that the participant felt belonged in one group. They were told to select their own criteria for grouping. All eighteen participants circled each of the four scenarios.

5. Results and Discussion

5.1 Data Collection and Analysis. For both of the experiments the data collection was the same. There are essentially two kinds of data collected for both the reconstruction and copying tasks. These are symbol placement times and order

of symbol placements. In the first case, one of two experimenters
records the times of the placement of symbols via a cassette
tape recorder. This procedure goes on until the participant
discontinues to place the symbols. This same experimenter also
keeps time for the five-seconds presentation in the reconstruction
task. For the copying task, in addition to recording the
symbol placement times, the experimenter records the times for
the beginning and end of a glance to the diagram from which the
participant is copying. The second type of data collected is
the order in which the symbols are placed on the blank diagram.
This data is collected by the second experimenter who stands
behind the participant and records the ordinals by using a blank
diagram and writing the ordinal number in the location corres-
ponding to that used by the participant to write the symbol.

There are four fundamental measurements that may be associated
with the data described above. These are: (a) the number of
accurately placed symbols; a symbol is placed accurately if both
its value and location are correct; (b) the order of placement of
accurately placed symbols; (c) the inter-placement times (IPT);
and (d) the within-glance symbol identification and time counts
for the copying task.

Several assumptions are made. First, in the copying task, it is assumed that successive glances to the diagram from which symbols are being copied, the stimulus diagrams, define the boundary of chunks. That is, the symbols that are placed on the response diagram between two glances to the stimulus diagram are referred to as the within-glance s--bols and considered to constitute a chunk. Second, the average IPT is computed for the within-glance symbols of each subject and used to define the chunk boundaries in the reconstruction task. Symbols placed at or below the computed IPT will be assumed to belong to the same chunk; those falling above the computed IPT will be considered to come from two different chunks, hence defining a chunk-boundary in the reconstruction task. Finally, the content characteristics of chunks in the reconstruction task is compared with those in the copying task. Chunk comparison, for both groups of subjects, is made on data characteristics such as the size of a chunk, IPT distributions, within chunk symbol relations and patterns, and order of chunk placements on diagrams. The order of placement is an indication of the importance of the chunk.

The data from the two experiments and the copying task were coded and entered for analysis at three levels of detail: symbol, chunk, and scenario. The data file for the symbol level analysis was built first from the raw experimental data on order of symbol placement, time of symbol placement, and accuracy. This raw data file was then entered to a computer program which "organizes" it according to various file outputs with chunks as the case unit. This program also adds the relational data to the raw symbol file. The average IPT for use in chunking the experimental data was computed from the copying task raw data (within glance inter-placement times) at 1.138 seconds. The times which fall within a glance in the copying task were averaged together to produce the IPT. (This was done with an option to the above computer program.) The symbol level raw data file was the input to another computer program which generated another file with the scenario as the case unit. The scenario file was used for statistical test on the accuracy of recall levels with respect to various modes of presentation. The contents of each data file are described as follows:

(1) Appendix III describes the raw data gathered for each symbol in each scenario. To this data file, tactical relation descriptions were added by a computer program. Also non-tactical formal relationships were added, e.g.,

spatial proximity, common color, common type.

(2) The chunk data file was generated by a program which
reads the raw data file, computes the IPT, and from _his
computes a set of IPT chunks for each scenario. The
program also contains a table of tactical relations
for each scenario. The program performs the following
functions:

a) update the raw data file to include chunk membership
for each symbol;

b) create a new file, with the chunk as case unit; this
file contains for each chunk:

  (1) identifying information -

       Experiment #
       Group
       Scenario
       Mode of presentation
       Chunk # (in order of placement)

  (2) placement time for 1st piece in chunk

  (3) # of pieces in chunk

  (4) % accuracy of chunk

  (5) relations between pieces in the chunk

  (6) # of relations in a chunk.

A computer program has been written that generates accuracy
data. The program reads raw data and computes the percent
of accurate symbol placement for each scenario. The output

of this program is a file with scenario as a case unit.

The file contains the following for each scenario:

a) identifying information ·

    Experiment #
    Group
    Scenario
    Mode of presentation

b) % accuracy for each scenario.

5.2 Presenting Chunked Information and the Accuracy of

Recall. The overall percent accuracy for comparing the various

modes of presenting chunked information is shown in Table 2. An

analysis of variance yields a significant main effect for modes

of presentation with $f(3, 92) = 8.317$, $p < .01$. It is clear

Table 2. The Overall % Accuracy and Standard
Deviations for the Four Modes of
Presentation.

Code	Value Label	%	Standard Deviation
1	Meaningful chunks	41.32	.1958
2	All-at-once	50.33	.1812
3	Non-meaningful chunks	31.44	.1453
4	Reverse chunks	29.33	.1331

from inspecting the means that presenting information sequentially
and incrementally by meaningful chunks results in higher
assimilation than if the same information is presented in a
sequence of non-meaningful chunks. A t-test comparing the two
means yields significance at $t(44) = 1.93$, $p < .06$. Also the
means show that the meaningful mode is significantly superior to
the mode where the meaningful chunks are presented in the reverse
order of reconstruction at $t(47) = 2.52$, $p < .05$. A t-test
yielded non-significant difference between the mode where the
chunks were presented all at once and that where they were
presented incrementally in meaningful chunks, at $p > 0.1$.

Those results suggest that not only is it important to
present information in meaningful structures, but in the case where
the information cannot be presented all at once, the effectiveness
of information assimilation increases when the meaningful
structures are presented in a proper sequence. It also may be
noted that the presentation of non-meaningful chunks resulted
in higher accuracies than the presentation of meaningful chunks
in the reverse-reconstruction order. This can be explained by
looking at the similarities of identically available symbols at
successive incremental labels between the meaningful, reverse,
and non-meaningful presentations. Table 3 makes it clear that
the non-meaningful and meaningful modes have many more symbols

Table 3. Mean Number of Symbols That are Available
Over the Three Scenarios For Each Increment
of Chunks

Increments	A	B
1	.33	0
2	1	0
3	2	0
4	5.33	0
5	9.67	3
6	11.33	8
7	15.67	14.33
8	21.33	20
9	24	24

A = Common symbols for non-meaningful and meaningful.
C = Common symbols for meaningful and reverse.

in common (9.67 for the three scenarios) after five increments

than do the meaningful and reverse (3 for the 3 scenarios).

Hence, the scenarios of the non-meaningful mode contain highly

meaningful structures for a longer period of time than do the

scenarios of the reverse mode. The availability of highly

meaningful structures for longer viewing and assimilation

durations may have lead to higher accuracy performance for the

non-meaningful conditions than for the reverse one.

5.3 The Effects of Sequential Context on Chunking Charac-
teristics and Accuracy of Recall. In order to determine the
effects of sequential context on accuracy of recall as well as on
certain key characteristics of the reconstructed chunks, several
comparisons between contextual modes were analyzed.

Accuracy. The extent to which the association between
scenarios is well or loosely structured may be inferred by
comparing the conditions where the scenario-to-be-reconstructed
is placed at either the start, the middle, or the end of a
sequence of scenarios. The assumption is that if there is a
significant difference on accuracy between the three conditions,
then a memory differential and interference effect may exist. If
on the other hand, there is no significant difference between the
three conditions, then it may be suggested that the viewer is
processing the salient feature, the foreground, of the entire
sequence and not simply the foreground of individual scenarios.
Table 4 shows an analysis of variance for the three conditions.
The analysis yields a non-significant F, hence supporting the
suggestion that the viewer is foregrounding the entire sequence
of scenarios.

A t-test comparison on accuracy of reconstruction between a
non-coherent sequence and a coherent one yielded non-significance
with $t(11) = 1.42$, $p > .1$. It is important to note that both

Table 4. Analysis of Variance for the Effect of the
Criterion Scenario Sequential Position by
Accuracy of Reconstructed Symbols

	Sum of Squares	Degrees of Freedom	Mean Square
Between Groups	.0037	(2)	.0018
Within Groups	.3203	(16)	.0200
Total	.3240	(18)	

F = .0918	SIG. = .9128	ETA SQRD = .0113

sequences contained the same invariant symbols, symbols that do
not undergo change from one scenario to the next. The reconstructed
symbols were constituted mostly of those that were invariant. This
result suggests that the invariant features of an information
display may be central to the process of assimilating and fore-
grounding. It may also be true that the availability of invariances
may have an effect on how information is chunked.

Chunk Characteristics. In order to determine the effects of
providing invariances in sequential context on various chunking
characteristics, a comparative analysis was made between the
condition where the criterion scenario is presented alone, and
the condition where it is presented in the context of a coherent

sequence of scenarios. The coherent sequence of scenarios

contains several invariant symbols.

It should first be noted that the reconstructed scenarios

were segmented into chunks using the interplacement time measure

(Badre, 1979). Table 5 shows that the average number of chunks

per scenario for all modes of presentation was 7.46. An analysis

Table 5. Analysis of Variance for Mean Number of
Chunks Per Scenario by Presentation
Context of Criterion Scenario

Context of Criterion Scenarios	Sum	Mean	Std Dev.	Sum of Square
First of 5	38.0000	7.6000	1.8166	13.2000
Middle of 5	49.0000	7.0000	2.4495	36.0000
Last of 5	45.0000	6.4286	3.4087	69.7143
Middle of 5 (unstructured sequence)	42.0000	7.0000	2.1909	24.0000
Single (alone)	65.0000	9.2857	3.1472	59.4286
Total	239.0000	7.4688	2.7590	235.9688

	Sum of Squares	Degrees of Freedom	Mean Square
Between Groups	33.6259	(4)	8.4065
Within Groups	202.3429	(27)	7.4942
Total	235.9688	(31)	

| $F = 1.1217$ | $SIG. = .3669$ | $ETA\ SQRD. = .1425$ |

of variance yielded a non-significant F. This finding replicates

earlier results (Badre, 1979), that the IPT measure yields a

$>$ $\pm$ 2 chunks per scenario.

In order to determine whether sequential context has an

effect on the size of a chunk, a comparative analysis was made

for the five modes of presentation. Two different units of chunk

content were used to determine size: symbols and tactical

relations between symbols. An analysis of variance for the means

in Table 6 yielded non-significance among the five modes with

respect to the number of symbols per chunk, with $F(4,26) = 1.802$,

Table 6. Means and Standard Deviations of the
Number of Symbols per Chunk for the
Five Modes of Contextual Presentations

Contextual Position of Criterion Scenario	Mean	Std. Dev.
First of 5	2.2000	1.4405
Middle cf 5	2.0000	.7071
Last of 5	2.9286	.9759
Middle of 5 (unstructured sequence)	2.8000	.8367
Single (alone)	1.8571	.5563

$p > .1$. This result is consistent with the no-difference results

over modes for accuracy of reconstruction and number of chunks

per scenario. A similar analysis for number of relations per

chunk yielded a non-significant $F(4,26) = .6905$, $p > 1$. The

average number of relations per chunk is 1.64.

An indirect way of determining the effects of an invariance

in a sequence of scenarios on assimilation effectiveness is to

examine the order in which symbols are reconstructed. Earlier

research showed that when a subject reconstructs a scenario, when

the scenario is presented out of context, he invariably places a

significantly greater number of red symbols in the first two

reconstructed chunks. A likely hypothesis is that an invariance

provides a basis for foregrounding displayed information and thus

is a focal point of information assimilation. Hence, if given a

group of invariant symbols all of which are blue, it is highly

probable that the participant would begin by reconstructing more

blue symbols than red ones in the first two reconstructed chunks.

In comparing the color of reconstructed symbols for the first

two chunks, between the sequential context mode and the mode where

the criterion scenario was presented alone, it was clear that the

availability of an invariance made a significant difference. For

the mode with no invariance, the percent of red symbols in the

first reconstructed chunk is 78%; for the first two reconstructed
chunks, it is 43%. This result replicates earlier findings.
For the presentation mode where an invariance is provided, the
percent of red symbols in the first two chunks is zero. The
difference betwe n the two modes for the mean number of red
symbols over the first two reconstructed chunks is significant
at $t(12) = 2.12$, $p < .05$. This finding is a clear indication
that the availability of invariances in information displays may
have an effect on chunk content and the way information is
perceived and organized.

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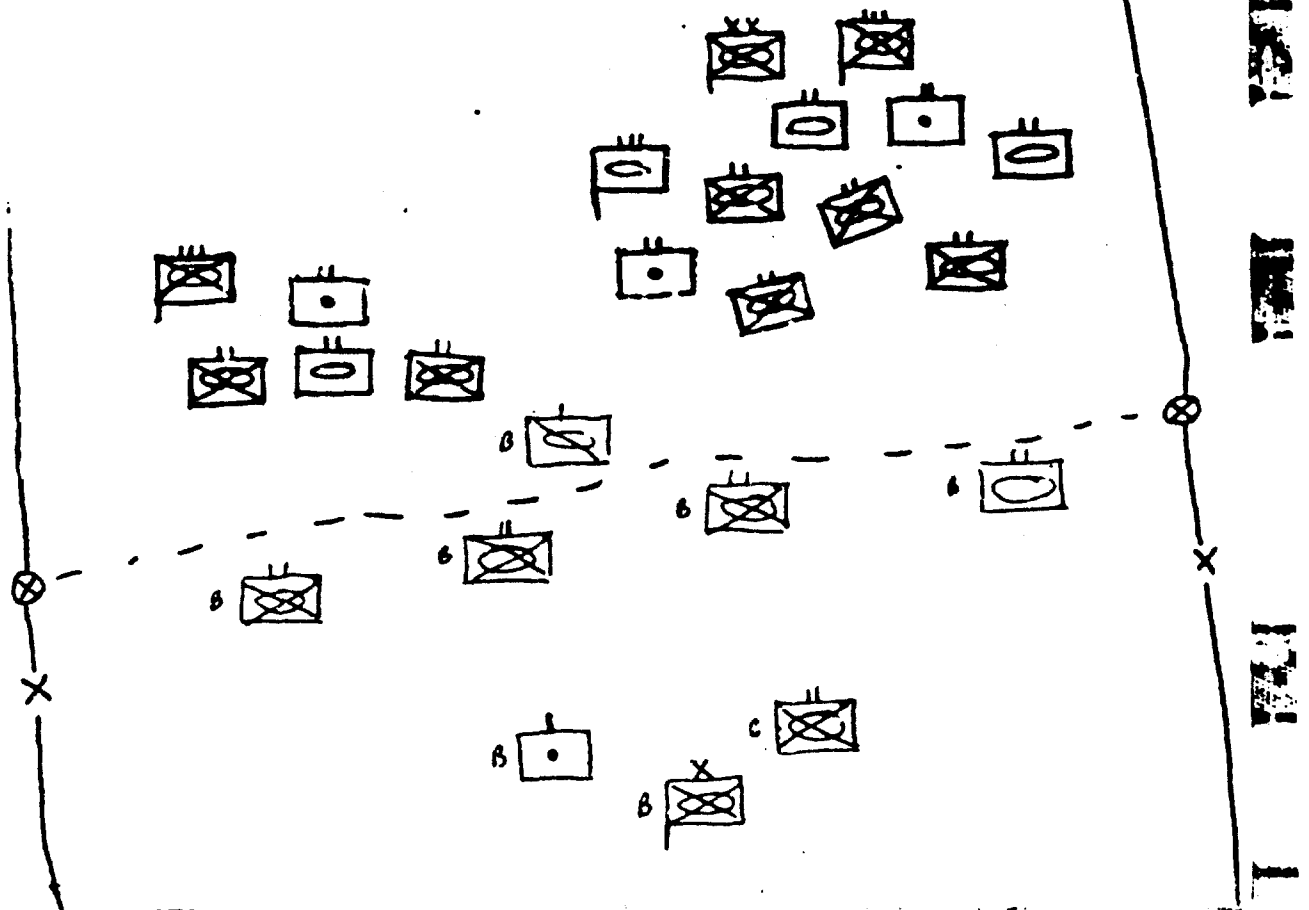
32
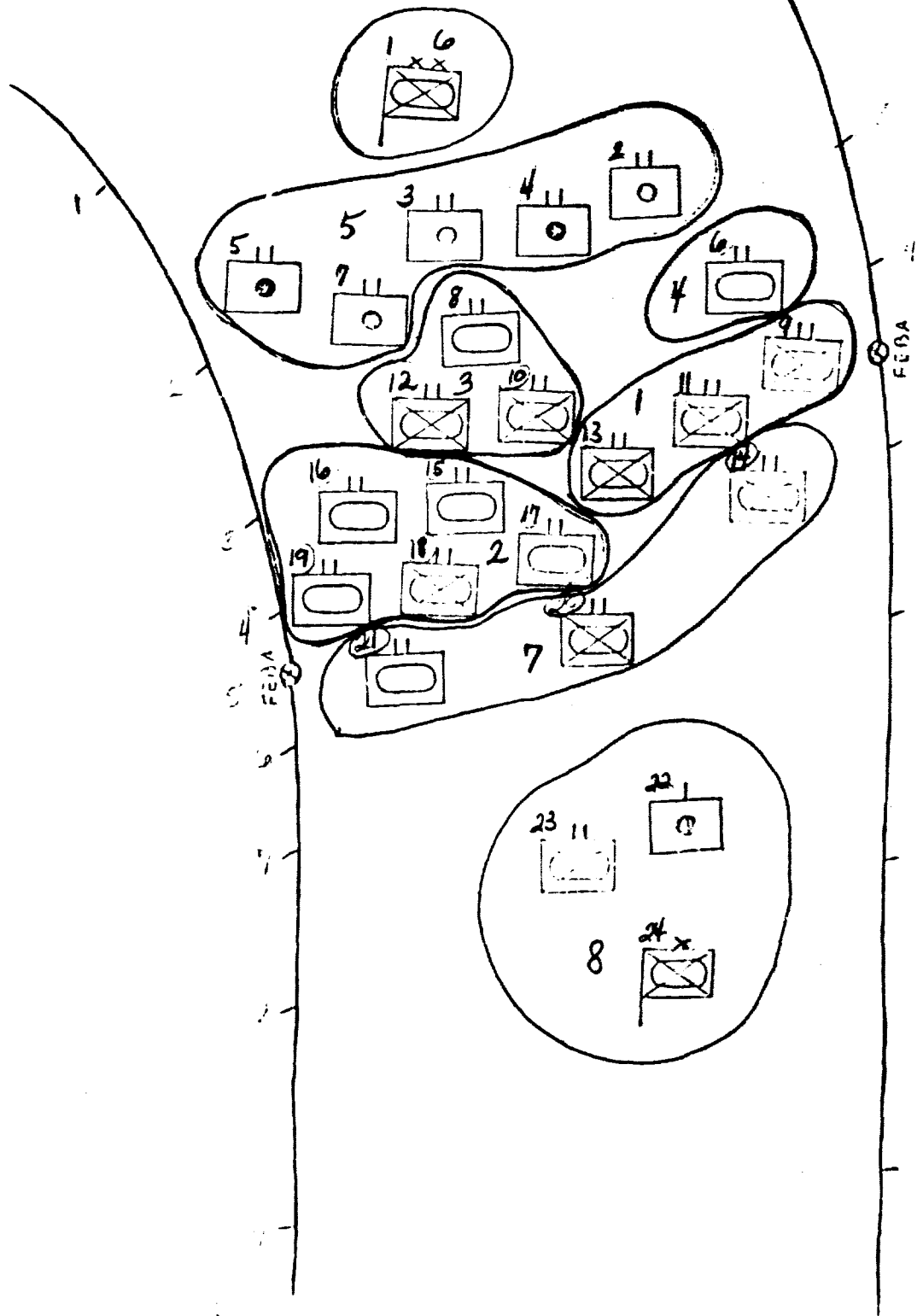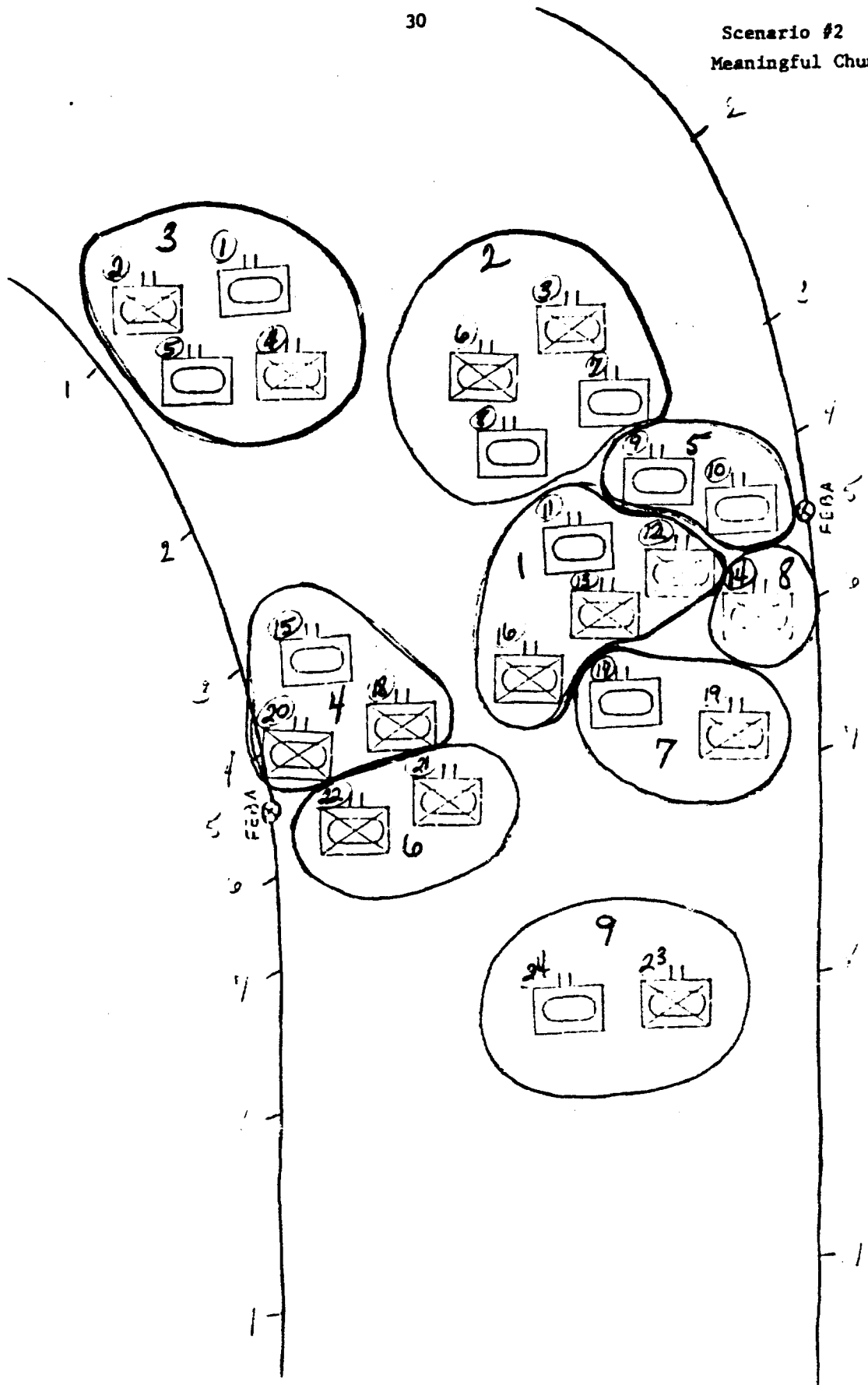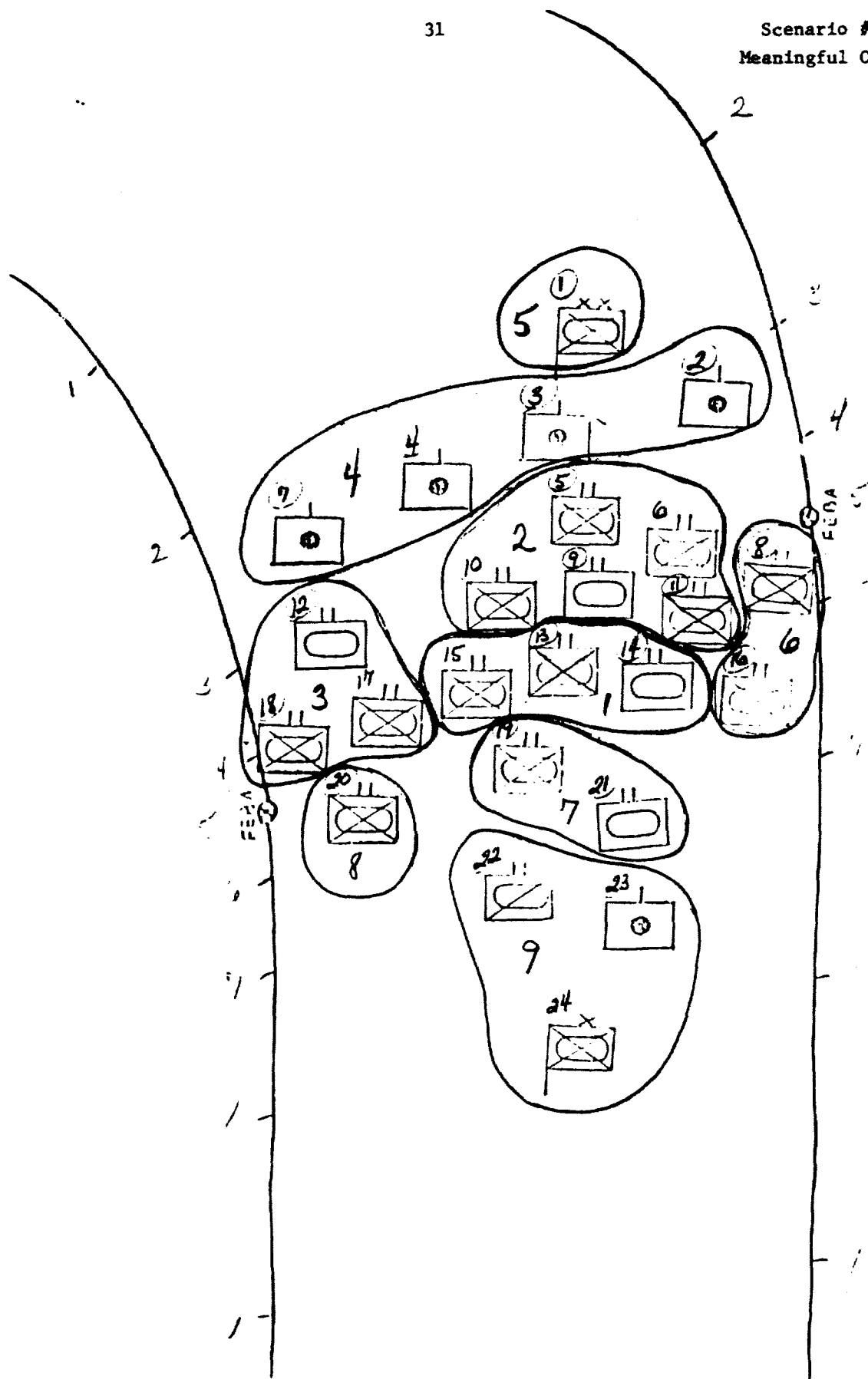
Units arrive in area

APPENDIX II
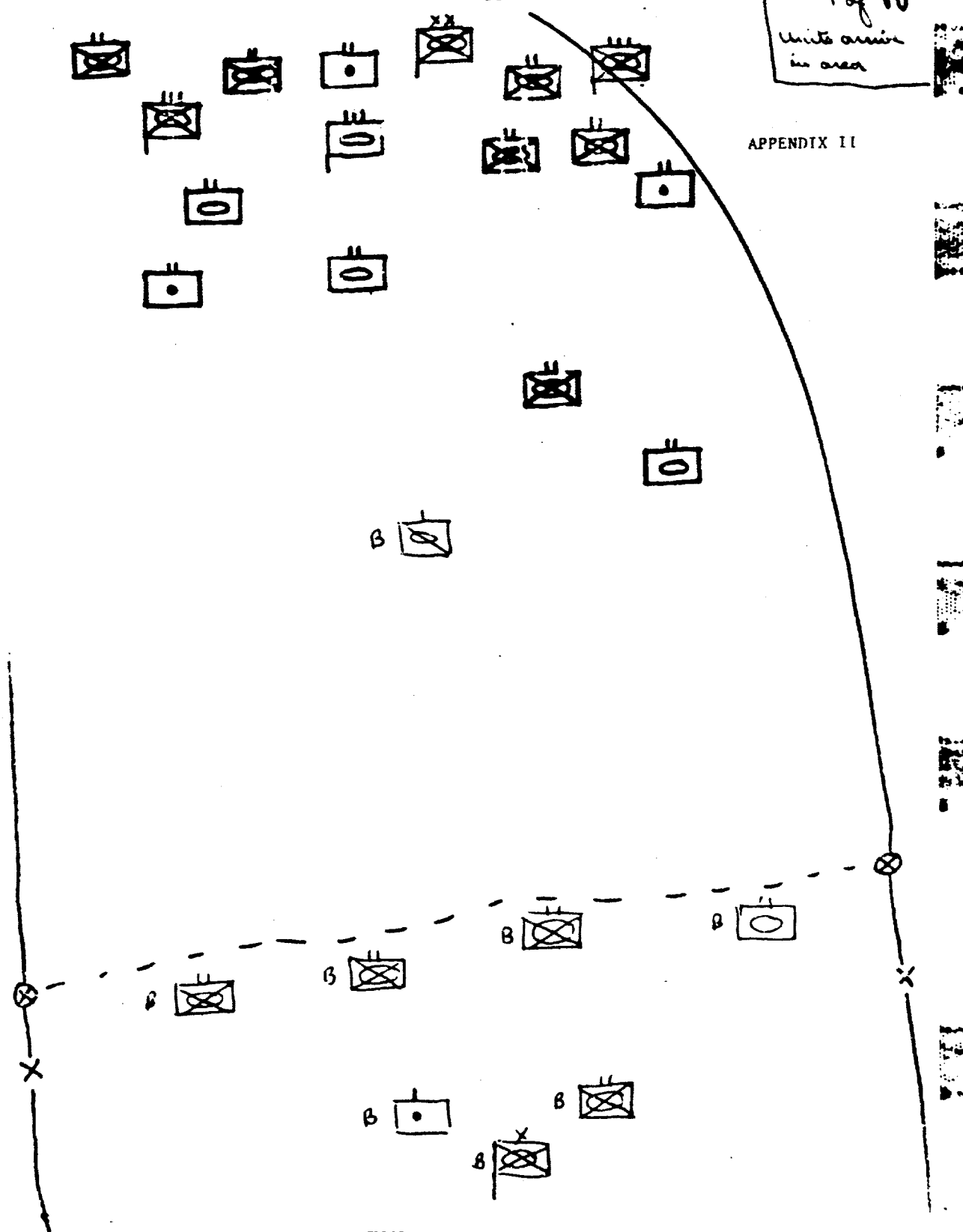
33
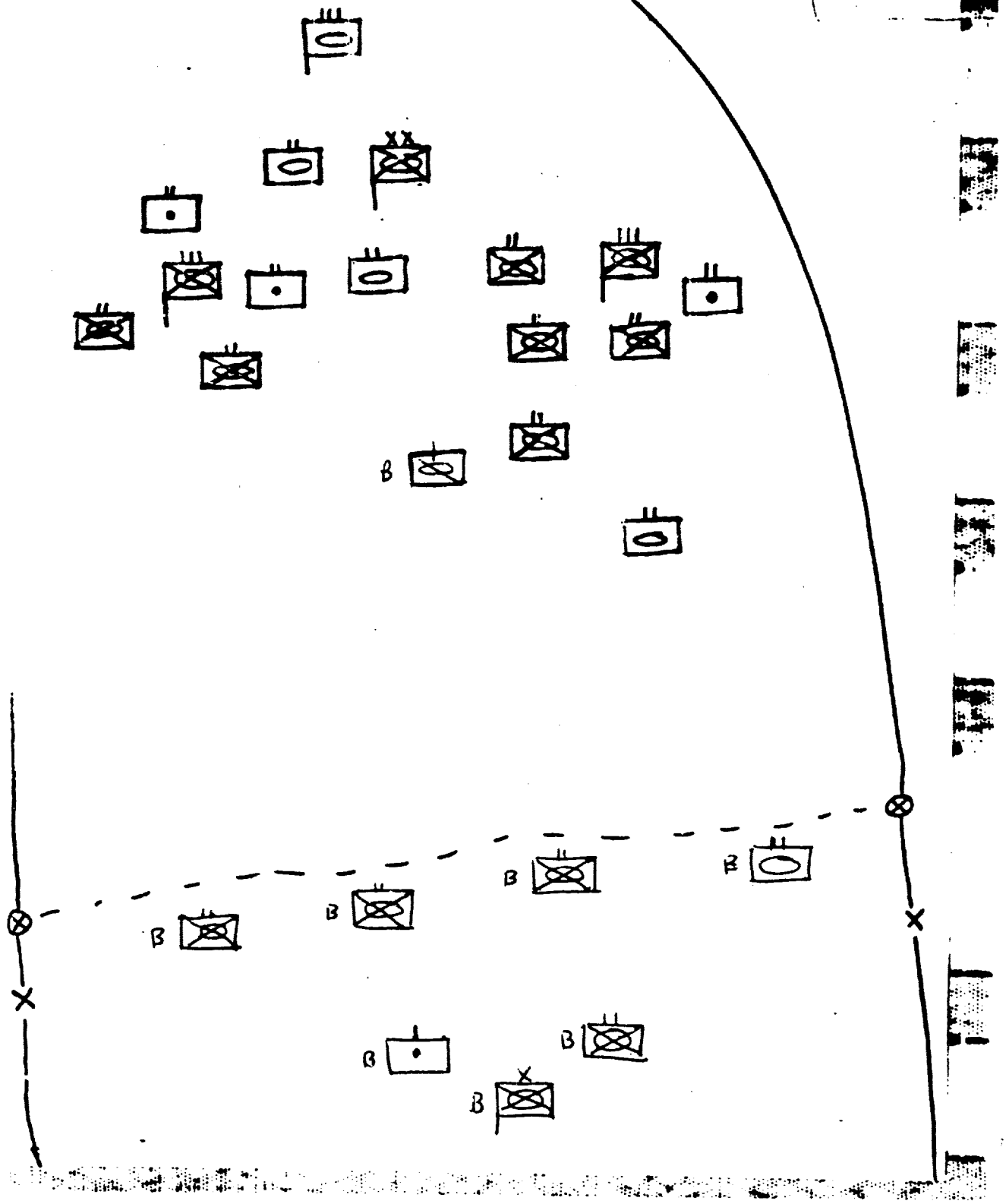
5q 10
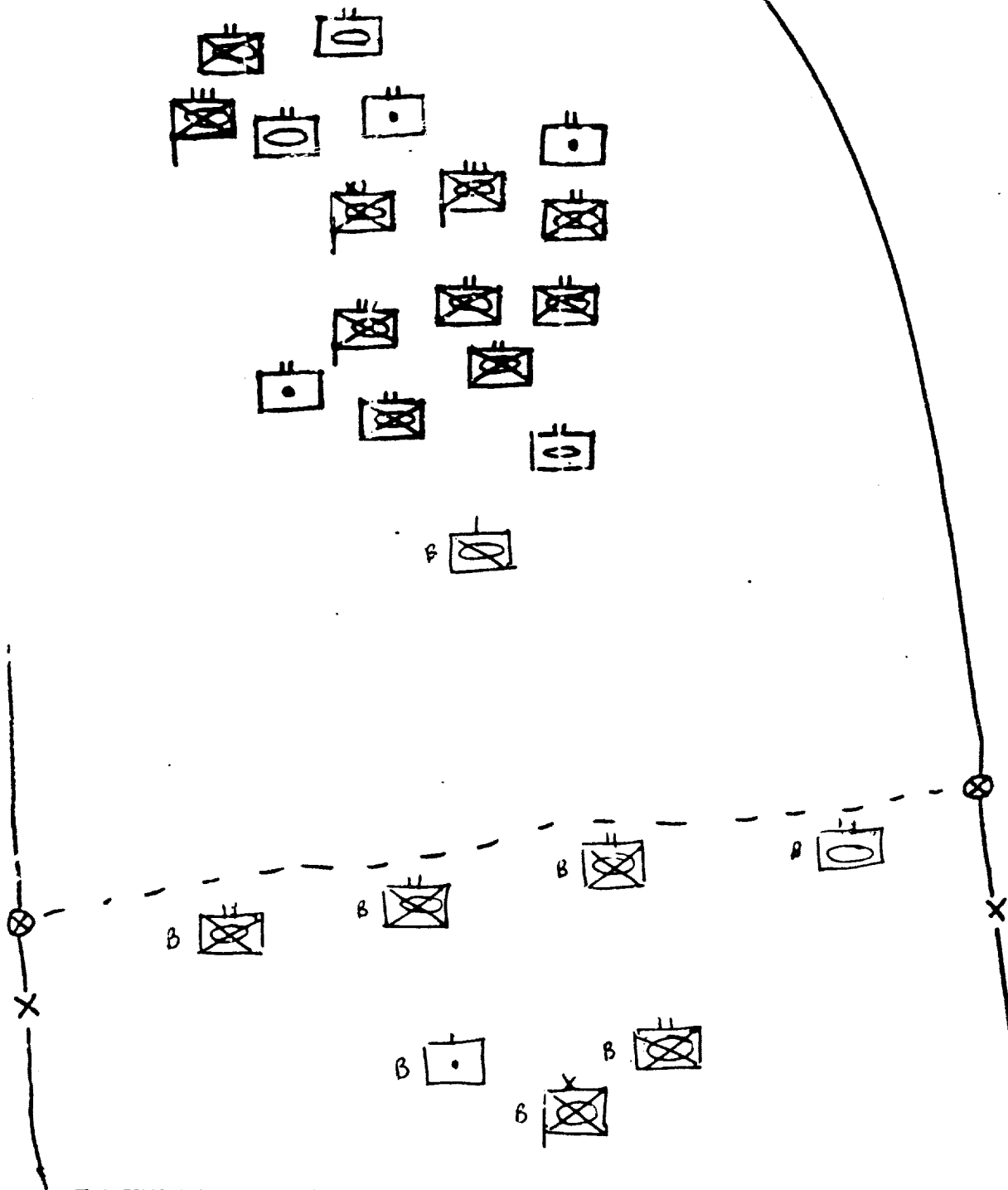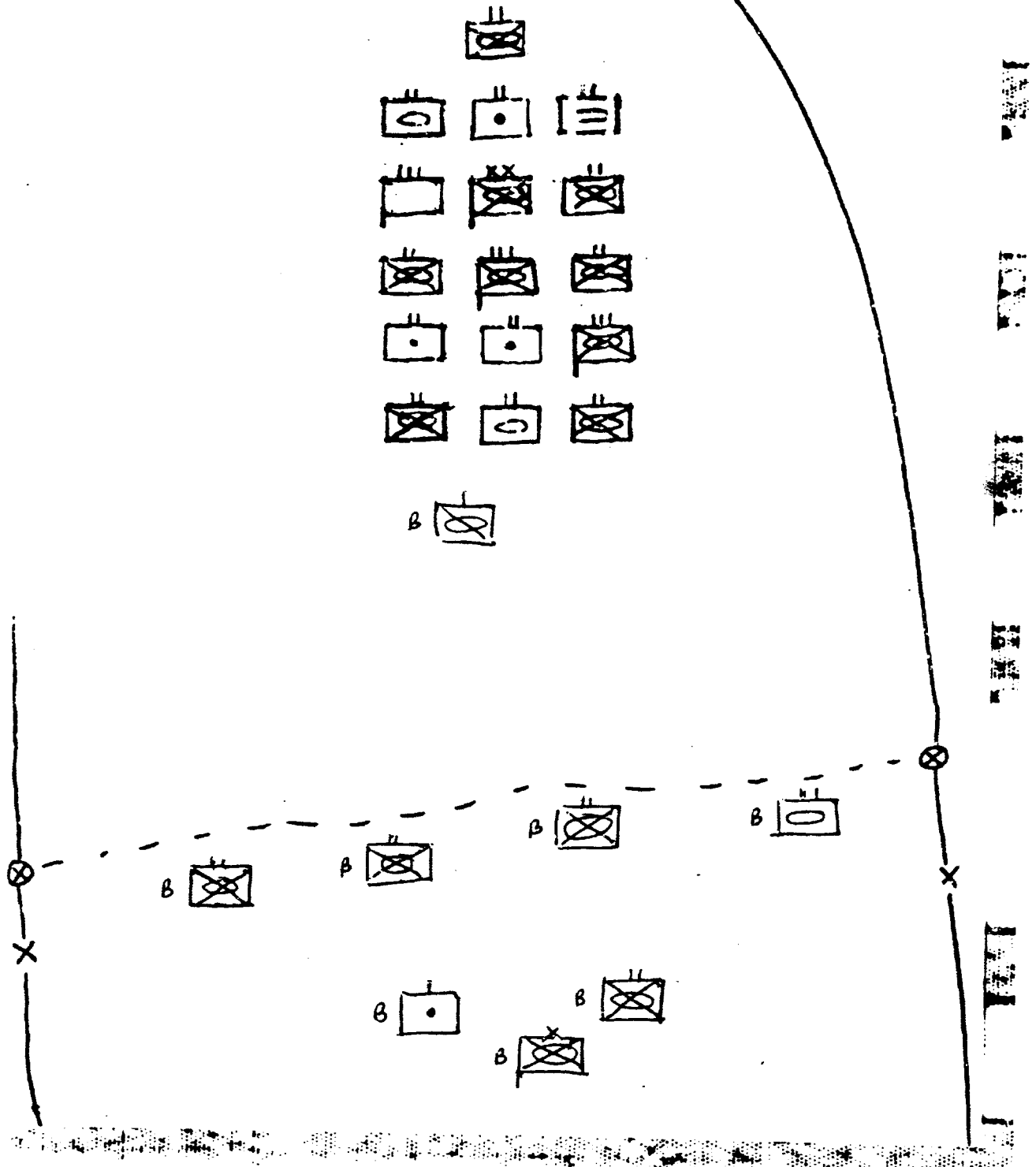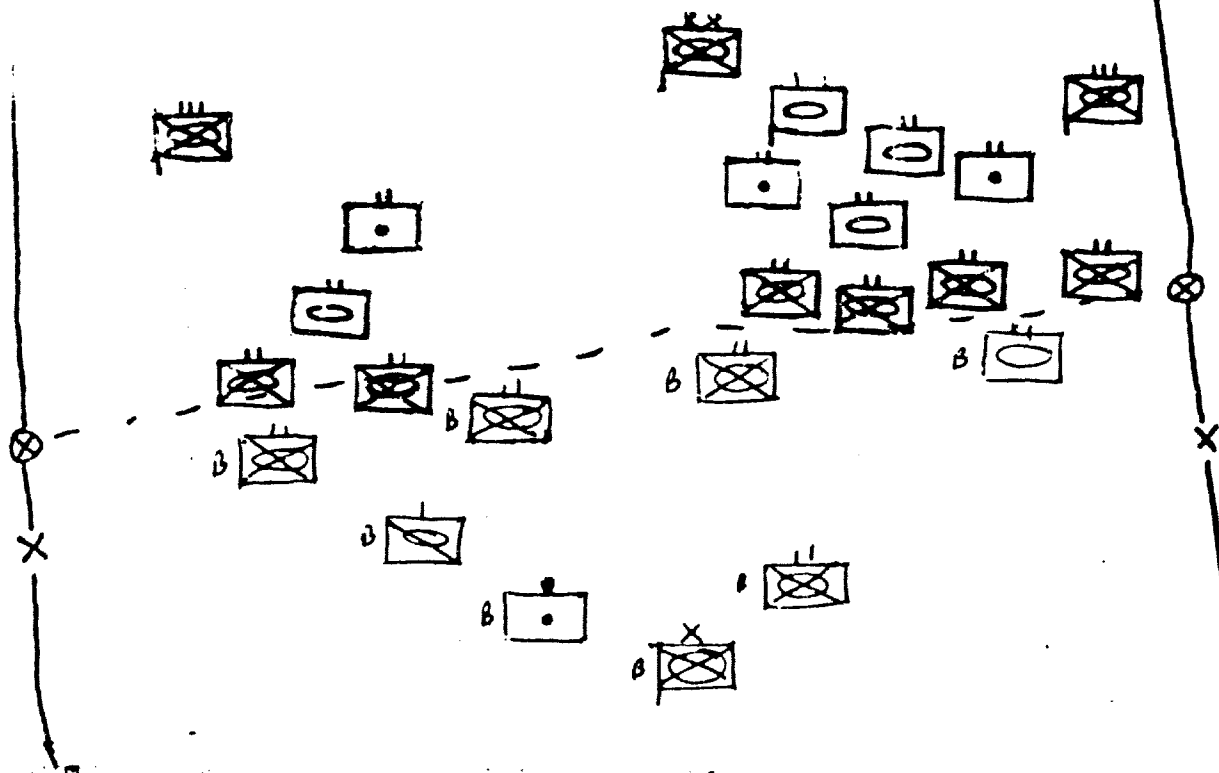
Units Engage Armoured
Car, start to
deploy in attack
formations
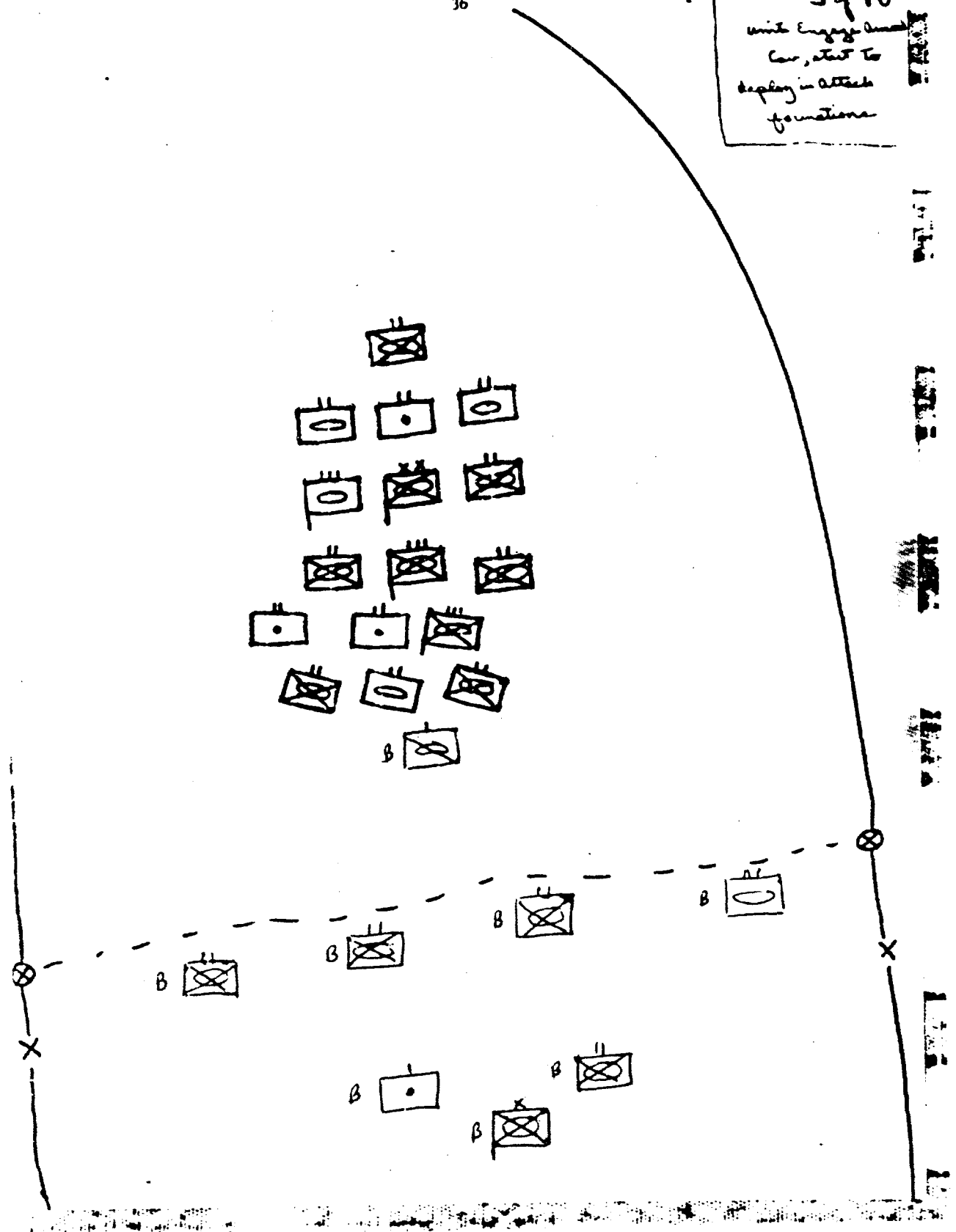
Units in attack formation for down secondary attack, and moving to attack formation for main attack

8 of 10
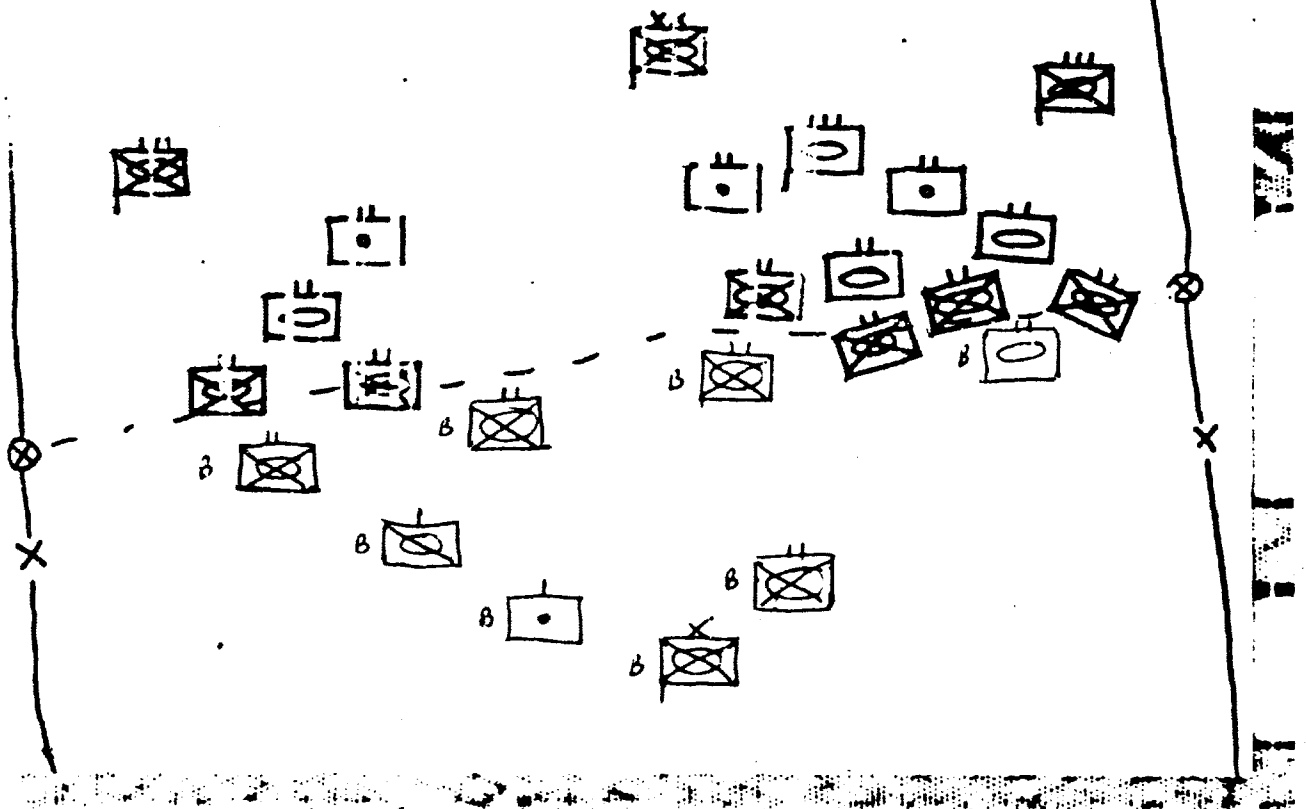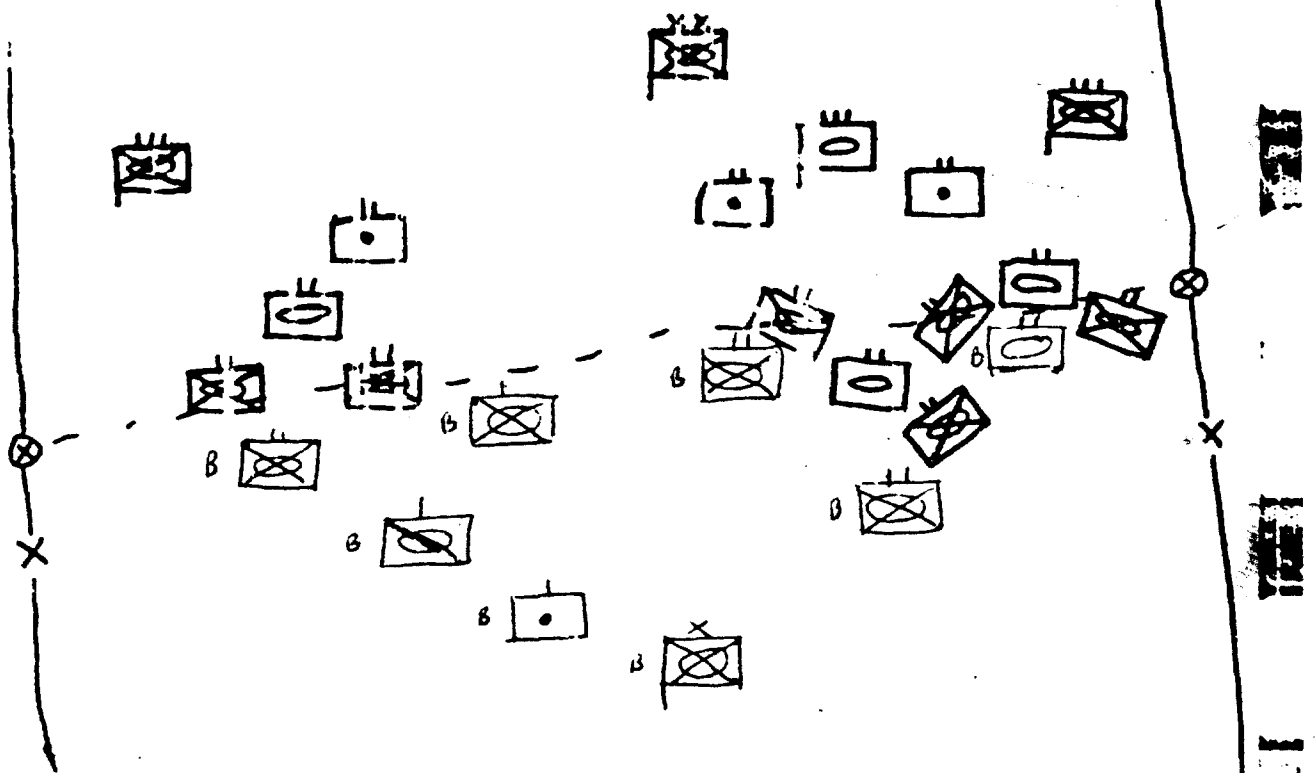Units continue
secondary attack and
start main attack

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APPENDIX III

Battlefield Scenarios   Raw Data File

	Data Item	Card Column	Form
1.	Subject # (01, ...28...)	1-2	I2
2.	Experiment # (1,2,3,4)	3	I1
3.	Scenario # $\begin{cases} \text{Exp.1} \rightarrow 1,2,3 \\ \text{Exp.2} \rightarrow 4 \end{cases}$	4	I1
4.	Mode of presentation $\begin{cases} \text{Exp. 1} \rightarrow M,A,N,R \\ \text{Exp. 2} \rightarrow F,M,E,S,R \end{cases}$	5	A1
5.	Data acquisition comments	7-8	I2
6.	Order of symbol placement (01...34)	10-11	I2
7.	Between glance indicator (0,1)	13	I1
8.	Placement ipt (# cycles (hex)) (0000...FFFF)	15-18	A4
9.	Symbol id# (99-no match) (01,...24,99)	20-21	I2
10.	Symbol color (1=Red, 2=Blue)	25	I1
11.	Color accuracy (0=no, 1=yes)	27	I1
12.	Symbol value (0,1,2,3,3-5,4,6,7,$\circ$,9-5)	29-30	I2
13.	Symbol value accuracy (0,1)	32	I1
14.	Subject placed symbol location ($\{A,B,C,D\}$,$\{1\rightarrow 8,F,X\}$)	35-36	2A1
15.	Static location accuracy (0,1)	38	I1
16.	Relative location accuracy (0,1)	40	I1
17.	Overall accuracy using 10,12,14 (0,1)	45	I1
18.	Overall accuracy using 10,12,15 (0,1)	47	I1
19.	Overall accuracy using 16,17 (0,1)	50	I1